



U.S. Army Research, Development and Engineering Command



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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US Army RDECOM ARDEC

Chromium Elimination and Cannon Life Extension for Gun Tubes

ESTCP WP-201111
ASETSDEFENSE OVERVIEW
August 30, 2012

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Function

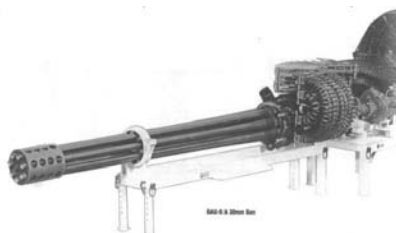
PI Program Manager
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Material Science
Material Science
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Technical Adviser
Cost Data Collection
Thermal Modeling
Explosive Analysis
Material Science
Manufacturing
Cladding Technology

- **To eliminate the use of hexavalent chromium (VI) in the production of cannon barrels by developing a cost effective environmentally friendly Explosive Bonding process.**
- **To demonstrate and validate the effectiveness of a cannon tube explosively clad with tantalum-10 tungsten (Ta-10W) liner to decrease erosion and increase performance and extend the lifecycle.**
- **The baseline for testing is a chromium plated gun tube.**



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Technical Approach



**High Rate GAU
Cannon Systems**



**BFV
25mm M242 Cannon**



M242 Bases C-RAM

**Explosive Bonding
Technology could
potentially be used
on the following
Legacy and New
Weapons Systems
Platforms.**



Mk 38 Tactical Standoff Systems



**Future GFV
30-50mm Cannons**



**High Mobility
Weapons**

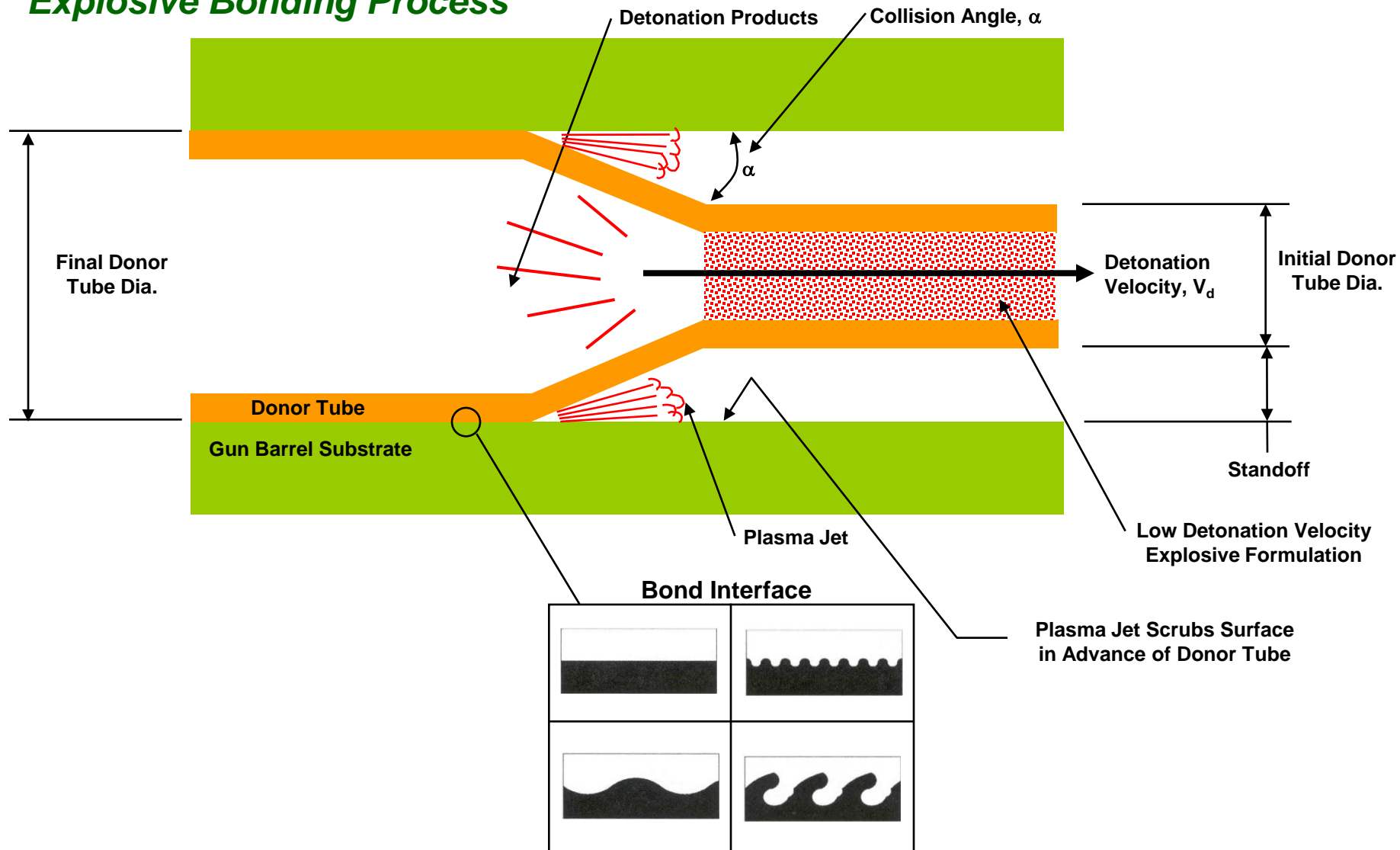


**Large Caliber Recoilless
Cannon Systems**

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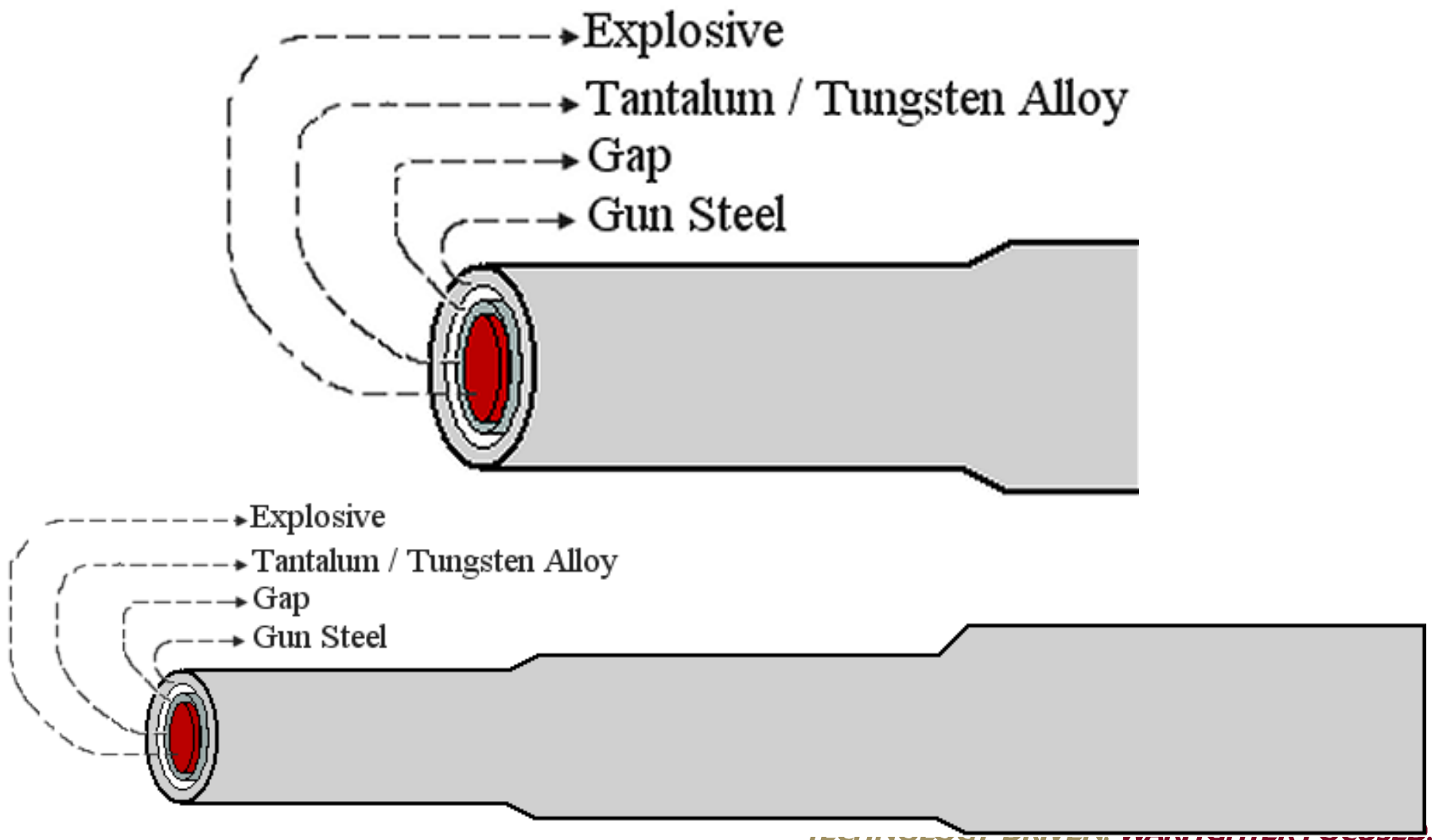
Technical Approach

Explosive Bonding Process

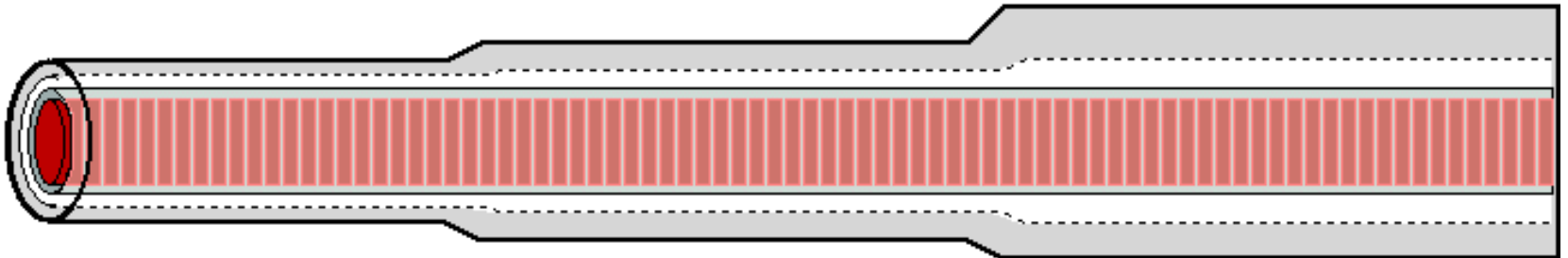




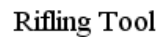
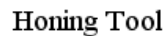
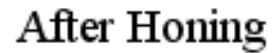
Explosive Bonding Process



Explosive Bonding Process

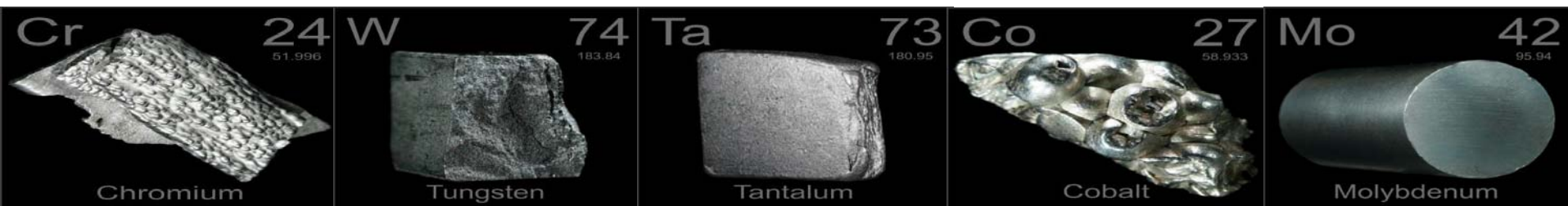


Before Honing





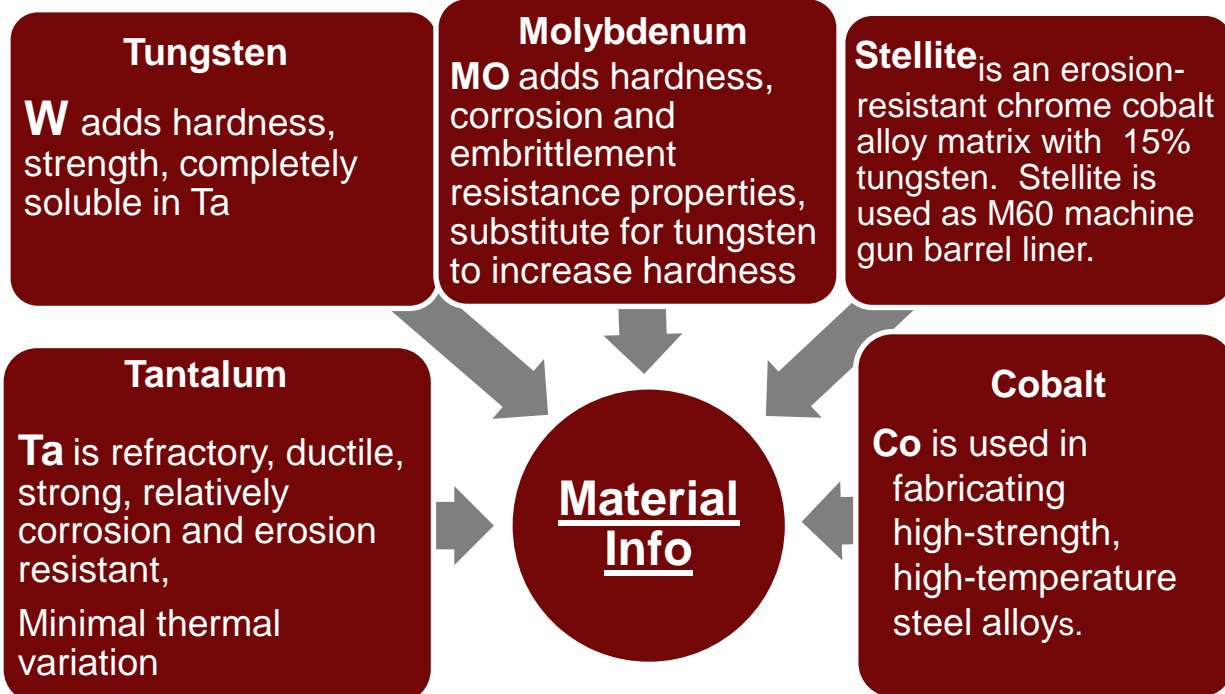
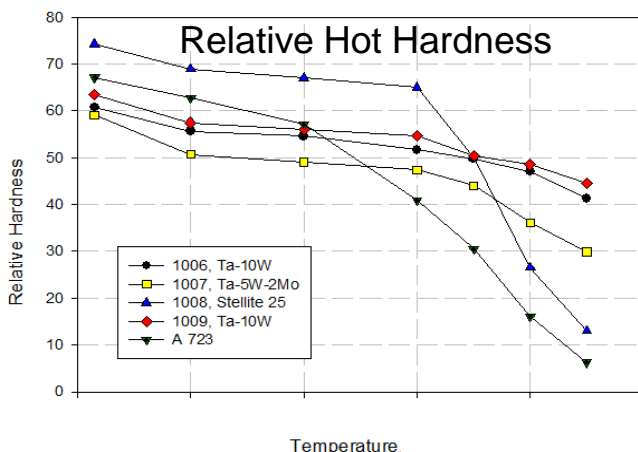
Technical Approach



Melting Point 1857 °C Melting Point 3422 °C Melting Point 3017 °C Melting Point 1495 °C Melting Point 2623 °C

Material Selection Goals:

1. Increased surface hardness for improved wear resistance
2. Reduced chemical reactivity including hydrogen embrittlement
3. Increased erosion resistance
4. Enhanced machinability to accommodate rifling
5. Reduce interface intermetallics



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Gun Steel to Ta-10W Bond Line



**Section of 18" Truncated Barrel
Ta-10W Donor Tube "Liner"**



**Sectioned 18" Truncated Barrel
Clad with Ta-10W**

Major Progress/Accomplishments 2011-2012

- **Demonstrational Test Plan for ESTCP Program WP-20111**
 - Developed, approved, and initiated
- **Firing Test Plan - JTP**
 - Developed and approved by ARDEC Medium Caliber Gun and Ammo Division
 - approved by APG
- **M242 25mm Barrels Fabricated**
 - S/N 101: Ta-10W
 - S/N 102: Ta-10W
 - S/N 103: Ta-10W
 - S/N 104: Ta-10W
- **Firing Test Conducted at YPG - High Energy Ammo Tests**
 - SN101 Ta-10W - using M919 and M791
 - SN7039 - using M919 and M791
- **Develop Advanced NDT Techniques for Weapon Systems**
I E. :UT CSCAN, CT-XRAY, 3D Measurements, EBIS

Demonstration Site:

Yuma Proving Grounds (YPG)

Preliminary proof of principle endurance testing at YPG shows promising results when conducted side by side to a chrome plated barrel.

The chrome barrel was condemned at 3,650 rounds.

At more than 12,000 rounds the Ta-10W tube.

The chamber was shown to be less than 1/3 worn when compared to the condemned chrome barrel.

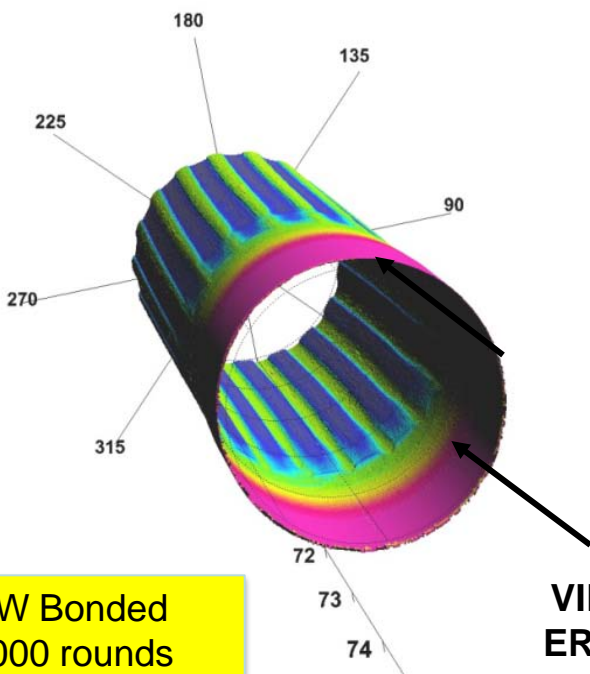
Virtually no wear on the tubes lands.



**Endurance Testing GP-20
Medium Caliber Range YPG**
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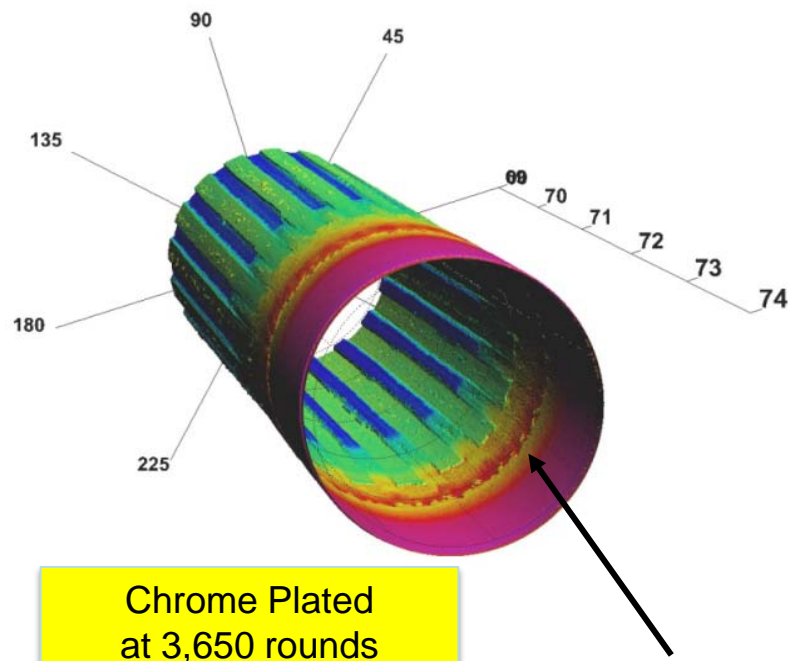
Overview of Prior Work

25mm M242 Barrel Ta-10W EB Liner Proof-of-Principle Testing



Ta-10W Bonded at 12,000 rounds

VIRTUALLY NO EROSION ON ID OF GUN STEEL



Chrome Plated
at 3,650 rounds

**WORN REGION
BELOW BORE ID
STEEL SURFACE**

Over 12,000+ rounds were fired through SN4 Ta-10W liner.
The liners: Steel baseline, HC on steel condemned at 3650 rounds.
The Ta-10W coated steel liner showed little sign of wear or erosion.

AND
OVE

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Technical Progress

NDT Recording Precision Measurements Over a Weapons Lifecycle



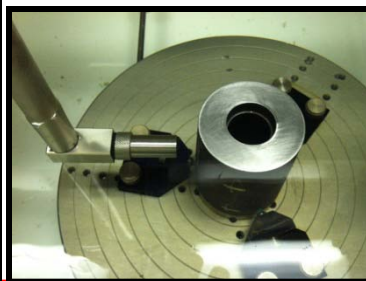
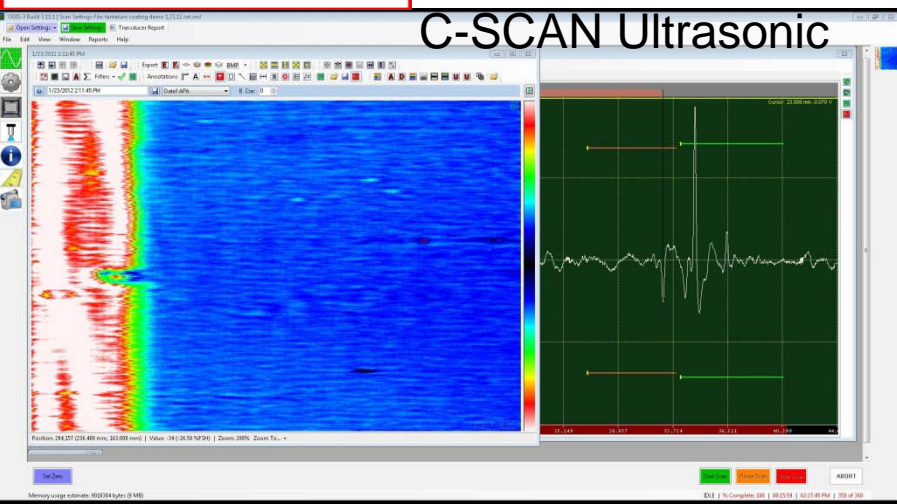
ARL-Aberdeen, MD

3D Optical Deformational
Analysis



Faro 3D CMM

C-SCAN Ultrasonic



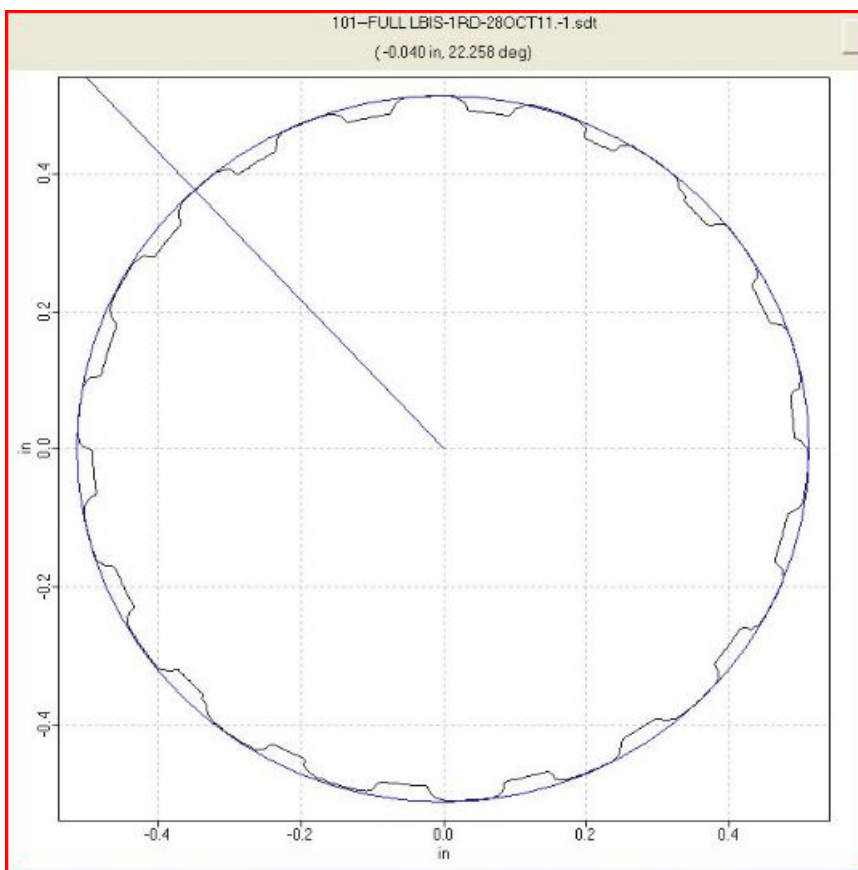
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Technical Progress

Firing Test Conducted at YPG - High Energy M919 Ammo Tests

Pre-Inspection – S/N 101: Ta-10W



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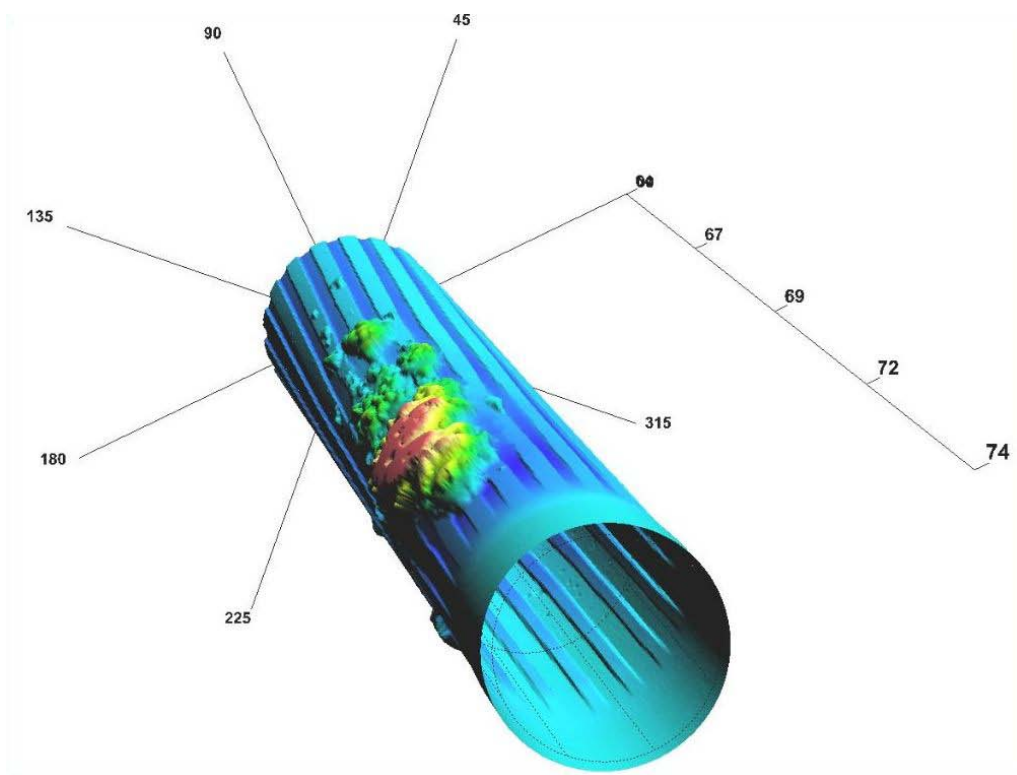


Technical Progress

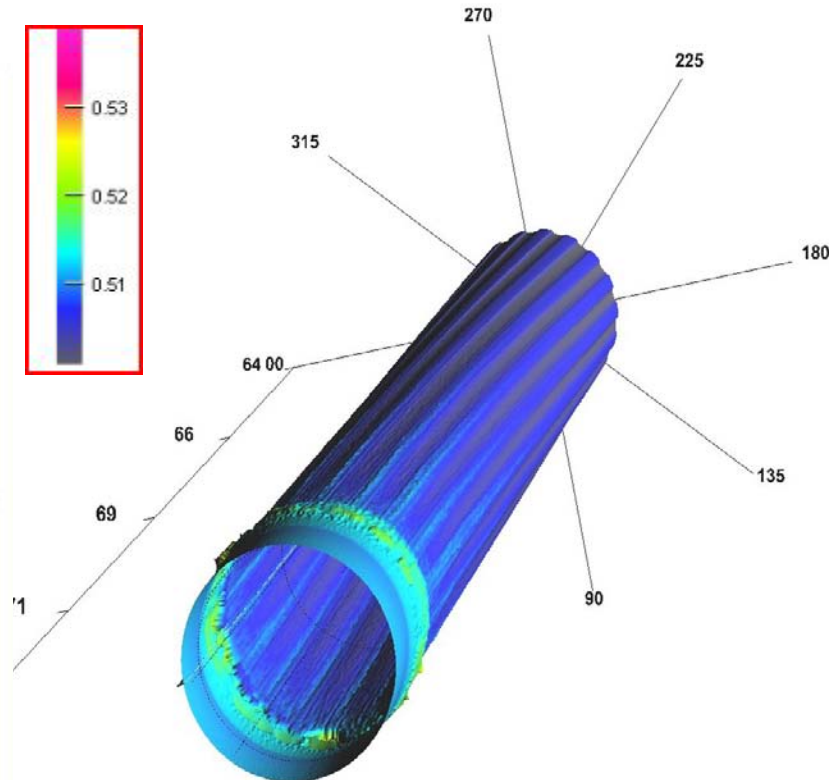
Firing Test Conducted at YPG - High Energy Ammo Tests

1. Visual Observations cont'd,

Chrome Tube 741 Rounds

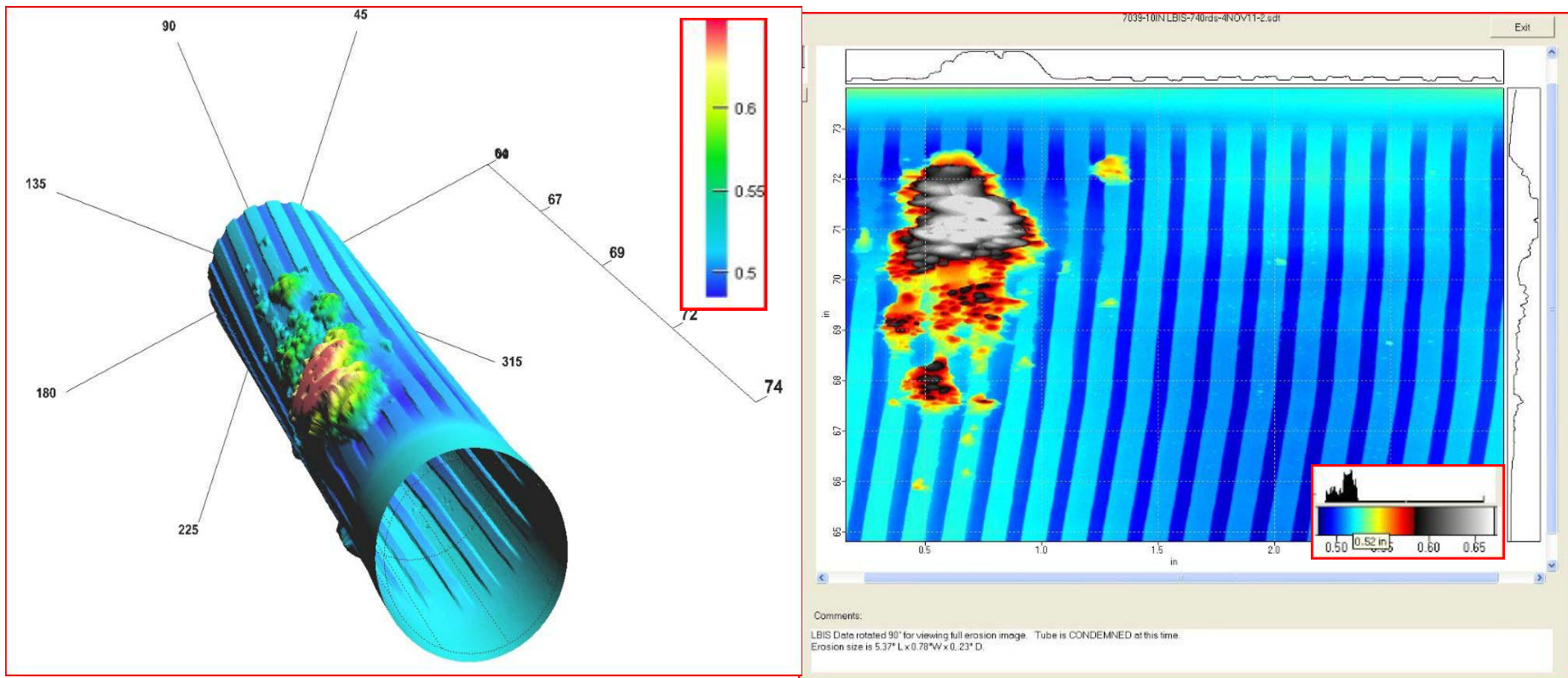


Ta-10W 900 Rounds



Firing Test Conducted at YPG - High Energy M919 Ammo Tests

1. Visual Observations – Chromium Tube at 740 Rounds



Post Firing - Inspection Catastrophic Failure at 740 rounds

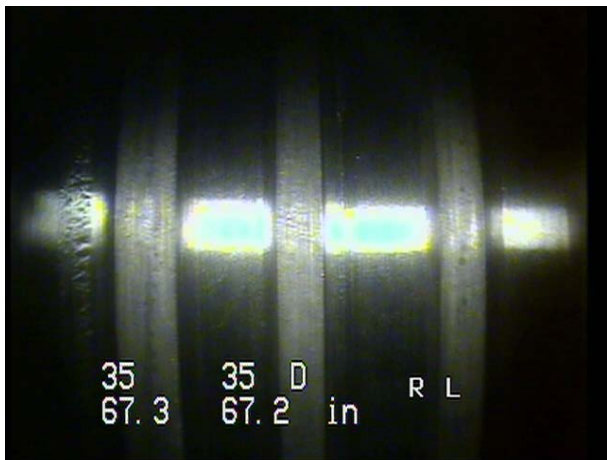
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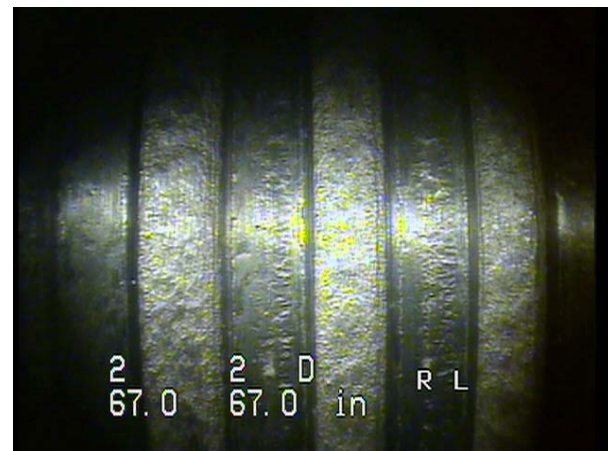
Technical Progress

Firing Test Conducted at YPG - High Energy M919 Ammo Tests

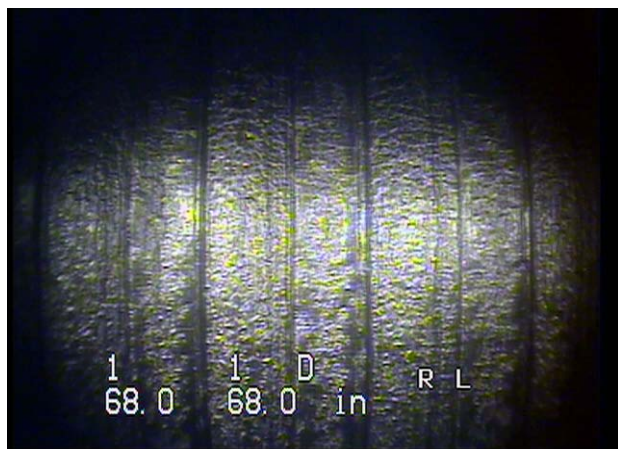
1. Visual Observations cont'd, Ta-10W Tube



1 Round



375 Rounds



750 Rounds



900 Rounds



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Large Caliber Work

Explosive Bonded Liner 105MM



RAREfaction waVE gun (RAVEN)

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- **Potential First DoD Users/Follow-on Implementation**
 - General Dynamics
 - Watervliet Arsenal
- **Responsible DoD/Service Programs**
 - PM CRAM
 - PM Bradley
- **Planned Future Technology Transfer Activities**
 - Leverage PM Support, Demonstrate to PM's
 - Institutional/Regulatory Barriers
 - None Known
- **Process Uses Traditional Metal Working Machinery**
 - No Investment In New Machinery, Buildings or Coating Apparatus



Results

• Previously Related Demonstrations

Under SERDP program WP-1426, verified the Explosive Bonding technology

- Explosively Bonded six 12", four 36" truncated 25mm barrels
- Explosively Bonded and test fired two full length M242 25mm barrels

Under ESTCP program WP-101111 verify the robustness of the Explosive Bonding technology

- Fully fabricated four Explosively Bonded full length M242 25mm barrels
- Test fired one barrel using original M919 APFSDS (HES-9053 propellant)

• Data Summary

- Initially proof fired M793TP-T projectiles
- Successful testing at YPG was demonstrated using over 12,000 aggressively fired rounds (M793/M791) 200 rounds per minute
- Ta-10W Barrel achieved a round count of three times the current baseline of chrome
- Successful testing at YPG was demonstrated using over 900 aggressively fired rounds (M919 APFSDS) 200 rounds per minute

Innovation is realized in:

- **The use of Explosion Bonding in applying refractory metals in gun barrels**
- **Use of advanced rifling/metalworking techniques (Patent Pending)**
- **Use of XRAY Tomography for NDT inspection of weapons**
- **Use of Laser scanner creating a 3D model "cloud of points" of weapon**

- **Recent Awards**
 - **2009 Army Research and Development Achievement (RDA) Award
EB Bonding and Machining Technologies**
 - **2009 Defense Manufacturing Excellence Award Tantalum Tungsten
Cannon Barrel Rifling Technology**
 - **2011 Army Science Conference R&E Award**



Questions?

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